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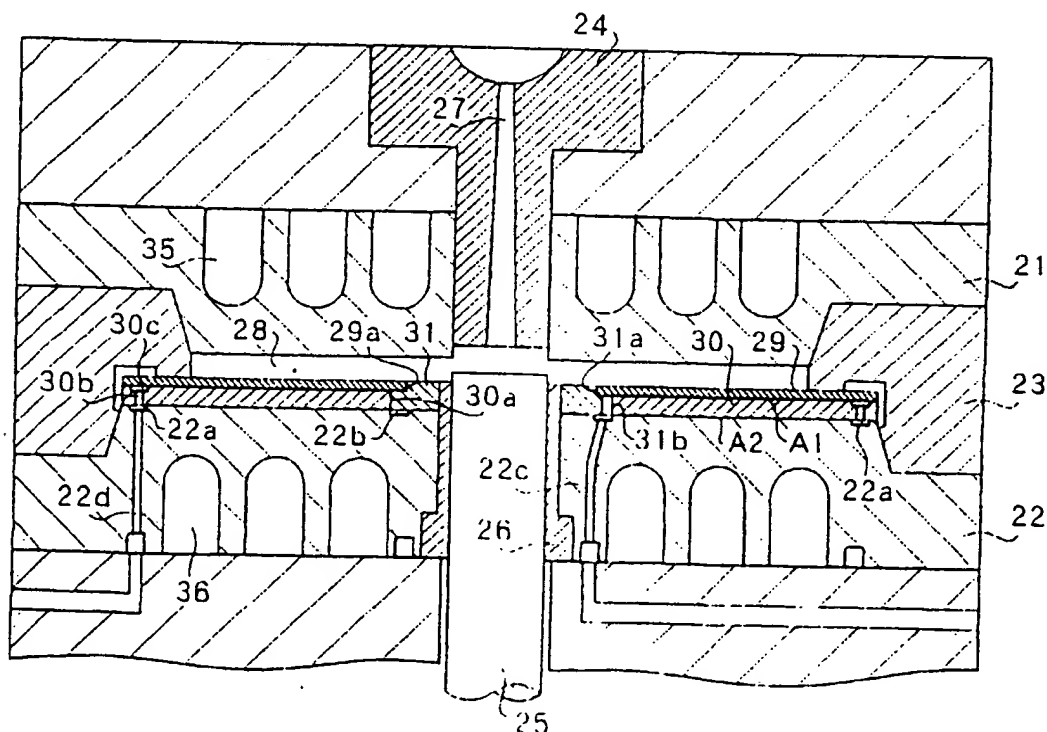
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(54) Metal mold apparatus for molding an optical disk

(57) In an optical disk molding metal mold apparatus, a stamper plate (29) is brought in close contact, by vacuum suction, with a faceplate of a cavity plate (22) via a disk-shaped plate (30). The difference between the deformation of the disk-shaped plate (30) caused by expansion and contraction thereof due to temperature changes and the deformation of the stamper plate (29) caused by expansion and contraction thereof due to

temperature changes during a molding cycle of the metal mold is smaller than the difference observed between the deformation of the stamper plate (29) caused by expansion and contraction thereof due to temperature changes and the deformation of the cavity plate (22) caused by expansion and contraction thereof due to temperature changes when the stamper plate is directly brought in close contact with the cavity plate.

FIG. 1



9 and the contact surface A1 of the movable cavity plate 2 which comes in contact with the stamper plate 9. In addition, it is also necessary to change the distance between a surface 3a provided on the outer periphery of stamper 3, which surface holds the stamper plate 9, and the contact surface A1 which comes in contact with the stamper plate 9. Thus, cumbersome changes of the shapes and dimensions of major components have been required for different types of stamper plates.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an optical disk molding metal mold apparatus which is capable of preventing the deterioration of the transcribing surface of a stamper plate caused by wear dust produced by the rubbing motion attributable to a difference in thermal expansion between a cavity plate and the stamper plate which is brought in contact with the cavity plate.

It is another object of the present invention to provide an optical disk molding metal mold apparatus which is capable of securely retaining different types of stamper plates without the need of changing major components in the aforesaid type of optical disk molding metal mold apparatus.

To these ends, according to the present invention, there is provided an optical disk molding metal mold apparatus which has a stamper plate brought in close contact with either one or both of the faceplate of a fixed cavity plate and the faceplate of a movable cavity plate which face against each other to form a cavity; wherein

the stamper plate is concentrically disposed on the faceplate or faceplates via a disk-shaped plate; and the materials of components are selected and the components are configured so that the difference between the deformation of the disk-shaped plate caused by expansion and contraction thereof due to temperature changes and the deformation of the stamper plate caused by expansion and contraction thereof due to temperature changes during a molding cycle of the metal mold which is cooled from the cavity plate side is smaller than the difference observed between the deformation of the stamper plate caused by expansion and contraction thereof due to temperature changes and the deformation of the cavity plate caused by expansion and contraction thereof due to temperature changes when the stamper plate is directly brought in close contact with the cavity plate.

In the optical disk metal mold apparatus, the materials of the components may be selected and the components may be configured so that, if the linear expansion coefficients of the stamper plate, the disk-shaped plate, and the faceplate are denoted as β_1 , β_2 , and β_3 , respectively, and the temperature change of the

stamper plate is denoted as Δt_1 , the temperature change of the disk-shaped plate is denoted as Δt_2 , and the temperature change of the faceplate on the disk-shaped plate side is denoted as Δt_3 in the molding cycle of the metal mold, and if $\Delta t_1 > \Delta t_2 > \Delta t_3$, then the following relationship is established: $\beta_1 \times \Delta t_1 > \beta_2 \times \Delta t_2 > \beta_3 \times \Delta t_3$.

Preferably, the linear expansion coefficient of the disk-shaped plate may be not less than the linear expansion coefficient of the stamper plate and not more than 6×10^{-6} per degree centigrade.

The stamper plate and the disk-shaped plate are concentrically supported by the cavity plate via an adapter having an outer peripheral section which fits in at least the central hole of the stamper plate.

The adapter may be designed to be a stepped cylinder providing different outer peripheral sections which fit in the central holes of the stamper plate and the disk-shaped plate, respectively.

The adapter has an outer peripheral section which fits at least in the central hole of the stamper plate and it may be designed so as to hold the circumferential edge of the central hole of the stamper plate by a jaw having a diameter which is larger than the central hole diameter of the stamper plate.

The adapter may be provided with a passage which is communicated with a suction passage provided on the cavity plate so as to attract the stamper plate by suction.

Near the outer periphery of the disk-shaped plate, a passage may be provided for attracting by suction the inside of the outer periphery of the stamper plate, the passage being communicated with the suction passage provided on the cavity plate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view showing an embodiment of an optical disk molding metal mold apparatus in accordance with the present invention;

FIG. 2 is a sectional view showing an enlarged view of a cavity section of the metal mold for injection-molding an optical disk substrate shown in FIG. 1;

FIG. 3 is a schematic diagram showing a further enlarged view of an essential section of the metal mold of the optical disk molding metal mold apparatus shown in FIG. 2; it illustrates a problem of a slight relative movement in a heat cycle;

FIG. 4 is a sectional view showing an embodiment of a first combination of a disk-shaped plate, an adapter, and a stamper plate used in the optical disk molding metal mold apparatus in accordance with the present invention;

FIG. 5 is a bottom view showing the first combination;

FIG. 6 is a sectional view showing an embodiment of a second combination of the disk-shaped plate, the adapter, and the stamper plate used in the optical disk molding metal mold apparatus in accord-

The heat of the molten resin 38 reaches the temperature control channel 36 provided in the movable cavity plate 22 via the stamper plate 29 and the disk-shaped plate 30 and it moves to temperature control water which is not shown. The molten resin 38, which has been charged in the cavity space 28, is then gradually cooled from the cavity plate side to solidify; it is taken out when it has been cooled down, for example, to about 70 degrees centigrade.

Referring to FIG. 3, the behaviors of the stamper plate 29 and the disk-shaped plate 30 when they expand and contract during the molding cycle will now be described in detail.

In the figure, T_1 , T_2 , T_3 , and T_4 denote the temperatures on an identical arbitrary radius: T_1 indicates the temperature, e.g. 340 degrees centigrade, of the molten resin 38, T_2 indicates the temperature of the contacting surface A1 between the stamper plate 29 and the disk-shaped plate 30, T_3 indicates the temperature of a contacting surface A2 between the disk-shaped plate 30 and the movable cavity plate 22, and T_4 indicates the temperature, e.g. 70 degrees centigrade or below, of the temperature control water, which runs through the temperature control channel 36 and which is not shown, or the temperature in the vicinity of the temperature control channel 36.

Normally, the temperature T_1 of the molten resin 38 is higher than the temperature of the temperature control water; therefore, the aforesaid temperatures present a temperature gradient which is expressed as $T_1 > T_2 > T_3 > T_4$ in the heat transfer process because of the rule of the heat conduction. It is more reasonable to consider that the temperature involved in the slight movement, namely, the expansion, of the contacting surface A1 between the stamper plate 29 and the disk-shaped plate 30 is the temperature at the central part of each plate thickness rather than the temperature T_2 on the contacting surface A1.

If the temperature of the central part of the stamper plate 29 is denoted by t_1 , the temperature of the central part of the disk-shaped plate 30 is denoted by t_2 , and the temperature in the vicinity of the polished surface of the movable cavity plate 22 is denoted by t_3 , then a relationship expressed by $t_1 > t_2 > t_3$ also applies.

In repeated molding process, if the maximum temperatures of the aforesaid t_1 , t_2 , and t_3 when the stamper plate 29 is held on the disk-shaped plate 30 by suction are respectively denoted by t_{1max} , t_{2max} , and t_{3max} , and the minimum temperatures are respectively denoted by t_{1min} , t_{2min} , and t_{3min} , then temperature differences Δt_1 , Δt_2 , and Δt_3 are defined as shown below:

$$\Delta t_1 = t_{1max} - t_{1min}$$

$$\Delta t_2 = t_{2max} - t_{2min}$$

$$\Delta t_3 = t_{3max} - t_{3min}$$

In this case also, the relationship expressed by $\Delta t_1 > \Delta t_2 > \Delta t_3$ is considered to be established.

Thus, when the molten resin 38 shown in the figure is charged in the cavity space 28, a point P_1 on the stamper plate 29 and a point P_2 on the disk-shaped plate 30, which correspond to the temperature changes Δt_1 and Δt_2 , respectively at the central parts of the plate thicknesses on the radius, expand by $\Delta L_1 = \beta_1 \times \Delta t_1$ and $\Delta L_2 = \beta_2 \times \Delta t_2$ which correspond to a linear expansion coefficient β_1 of the stamper plate 29 and a linear expansion coefficient β_2 of the disk-shaped plate 30, respectively. After that, the molten resin 38 is deprived of heat by the temperature control water and it completes its solidification, causing the stamper plate and the disk-shaped plate to restore the original states thereof.

As a result, a slight relative movement ΔL of the stamper plate 29 with respect to the disk-shaped plate 30 is expressed by $\Delta L = \Delta L_1 - \Delta L_2 = \beta_1 \times \Delta t_1 - \beta_2 \times \Delta t_2$. Hence, in order to minimize the slight movement ΔL , the linear expansion coefficient β_2 of the disk-shaped plate 30 must be at least equal to or larger than the linear expansion coefficient β_1 of the stamper plate 29 according to the relationship of $\Delta t_1 > \Delta t_2$.

Therefore, in this embodiment, the pure nickel steel which is the same material used for the stamper plate 29 is employed for the disk-shaped plate 30 as previously mentioned so as to provide the same linear expansion coefficient. The linear expansion coefficients of nickel are 13.4×10^{-6} , 15.3×10^{-6} , and 16.8×10^{-6} at 293°K , 500°K , and 800°K , respectively.

Further, the thickness of the disk-shaped plate 30 is set based on the temperature T_1 of the molten resin 38, the temperature T_4 of the temperature control water, and the heat conductivity of the pure nickel steel so that the difference between the average temperature Δt_1 and Δt_2 of the central parts of the stamper plate 29 and the disk-shaped plate 30, respectively, is minimized.

If the pure nickel steel is employed for the stamper plate and a different material is employed for the disk-shaped plate, then the linear expansion coefficient β_2 of the disk-shaped plate 30 should preferably be not less than the linear expansion coefficient β_1 of the stamper plate but not more than 6×10^{-6} per degree centigrade. This enables the stamper plate 29 to have an extremely small relative movement ΔL with respect to the disk-shaped plate 30, thus permitting reduced wear on the stamper plate 29. The top and bottom surfaces of the disk-shaped plate 30 are polished and smoothed to have specular surfaces so as to minimize the contact heat resistance on the surfaces A1 and A2, shown in FIG. 2 and FIG. 3, which respectively contact with the stamper plate 29 and the movable cavity plate 22.

In this embodiment, the movable and fixed cavity plates employ stainless steel. The linear expansion coefficient β_3 of stainless steel is 14.7×10^{-6} , 17.5×10^{-6} .

locking modes of the stamper plate can be achieved simply by the adapter and the disk-shaped plate. This obviates the need for changing the dimensions of the components in the metal mold as in the conventional apparatus, thus making it possible to provide a standardized metal mold with higher value added. 5

Claims

1. An optical disk molding metal mold apparatus which has a stamper plate brought in close contact with either one or both of the faceplate of a fixed cavity plate and the faceplate of a movable cavity plate, the two cavity plates facing against each other to form a cavity; wherein 10

the stamper plate is concentrically disposed on the faceplate or faceplates via a disk-shaped plate; and

the materials of components therefor are selected and the components are configured so that the difference between the deformation of the disk-shaped plate caused by expansion and contraction thereof due to temperature changes and the deformation of the stamper plate caused by expansion and contraction thereof due to temperature changes during a molding cycle of the metal mold which is cooled from the cavity plate side is smaller than the difference observed between the deformation of the stamper plate caused by expansion and contraction thereof due to temperature changes and the deformation of the cavity plate caused by expansion and contraction thereof due to temperature changes when the stamper plate is directly brought in close contact with the cavity plate. 20 25 30 35

2. An optical disk molding metal mold apparatus according to Claim 1, wherein the materials of the components are selected and the components are configured so that, if the linear expansion coefficients of the stamper plate, the disk-shaped plate, and the faceplate are respectively denoted by β_1 , β_2 , and β_3 ; and 40 45

the temperature change of the stamper plate is denoted by Δt_1 , the temperature change of the disk-shaped plate is denoted by Δt_2 , and the temperature change of the faceplate on the disk-shaped plate side is denoted by Δt_3 ; and if $\Delta t_1 > \Delta t_2 > \Delta t_3$ is true, then a relationship expressed by $\beta_1 \times \Delta t_1 > \beta_2 \times \Delta t_2 > \beta_3 \times \Delta t_3$ is established. 50 55

3. An optical disk molding metal mold apparatus according to Claim 1, wherein the linear expansion co-

efficient of the disk-shaped plate is preferably not less than the linear expansion coefficient of the stamper plate and not more than 6×10^{-6} per degree centigrade.

4. An optical disk molding metal mold apparatus according to Claim 1, wherein the stamper plate and the disk-shaped plate are concentrically supported by the cavity plate via an adapter which has an outer peripheral section which fits in at least the central hole of the stamper plate. 10
5. An optical disk molding metal mold apparatus according to Claim 4, wherein the adapter is a stepped cylinder which has different outer peripheral sections which respectively fit in the central hole of the stamper plate and the central hole of the disk-shaped plate. 15
6. An optical disk molding metal mold apparatus according to Claim 4, wherein the adapter has an outer peripheral section which fits in at least the central hole of the stamper plate and which holds the circumferential edge of the central hole of the stamper plate by a jaw having a larger diameter than the central hole of the stamper plate. 20 25 30
7. An optical disk molding metal mold apparatus according to Claim 4, wherein the adapter is provided with a passage which is communicated with a suction passage provided on the cavity plate to attract the stamper plate by suction. 35
8. An optical disk molding metal mold apparatus according to Claim 4, wherein a passage is provided near the outer periphery of the disk-shaped plate in such a manner that it is communicated with a suction passage provided on the cavity plate so as to attract the inside of the outer peripheral section of the stamper plate by suction. 40 45 50 55

FIG. 2

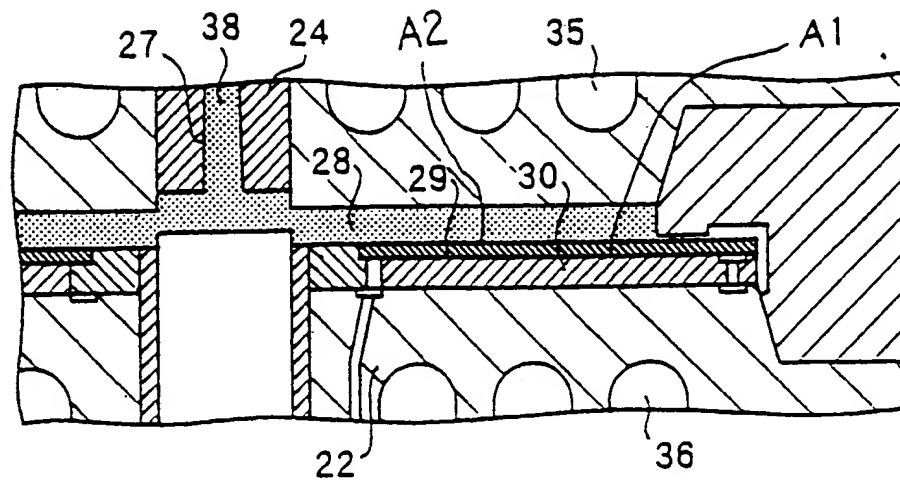


FIG. 3

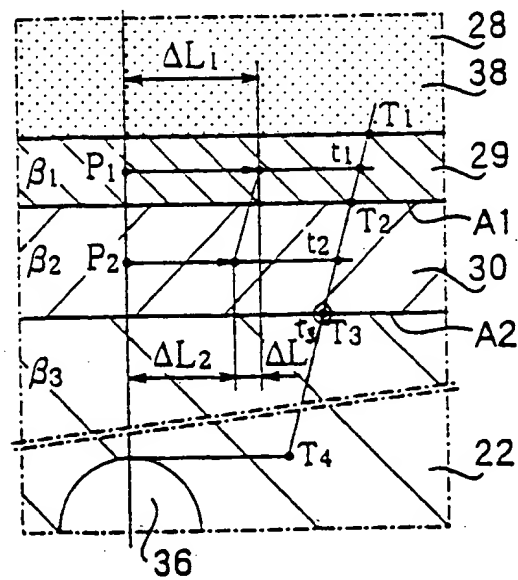


FIG. 6

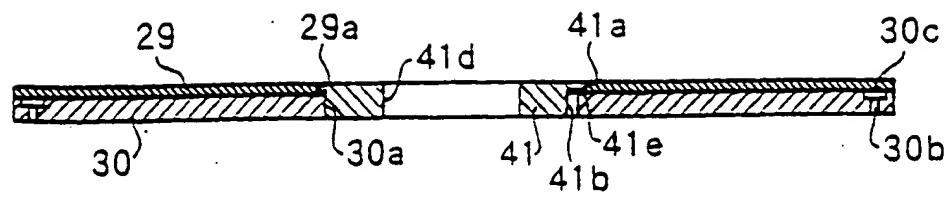


FIG. 7

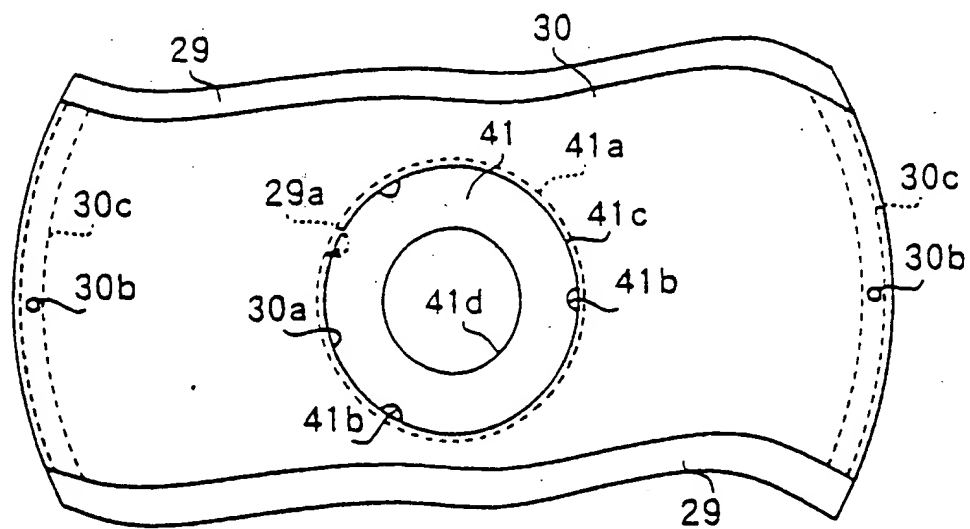


FIG. 10

